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Robust Visual Multi-Target Trackers: A Review

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ABSTRACT

In this review paper, we address on the state-of-art process with visual object tracking in video surveillance, medical and military applications. In the present scenario number of algorithms and methods are used to track the object in the different scene, a robust visual object tracking remains a critical challenge. The challenges arise due to object motion from frame to frame with a change in appearance, structures, illumination, and occlusion. In this paper, at last, we outline the different algorithms, dataset, strength, and weakness of the different object tracker.

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1. INTRODUCTION

In computer vision with the real-time visual object, Tracking remains a critical challenge. The challenges arise due to noise in the image, reflection background, computational problem in dynamic object motion, clutter based background, illumination changes in the static and dynamic image, partial or full occlusions which occur in real time processing etc [1, 2]. In the real world the images will be in 3D, when which is projected in 2D there will be a big loss of data.

Tracking is the process of monitoring the object frame by frames, from its first manifestation to its end destination. The type of target and its characteristics description within the system depends on the application. Robustness and efficiency tracking are the two main challenges existing in trackers. Most of the robust trackers are implemented with single or combination features with a high computational cost.

The enhancement of the tracker robustness using multi-view model with discriminative parameters. As well as effective tracker should be handling with variations of the object and its background. The Generative and discriminative are two approaches used in tracking of single or multi-objects in computer vision. The Generative approach uses a model based and classical tracking methods to track moving object. Discriminative object tracking algorithms are mainly established on deep learning methods. The main drawback of this algorithm is that it may require a larger number of training dataset.

In this review paper, two directional aspects are there, one aspect is to review on, how the robust tracker's interposition with several challenges. The other is to tabulate which are the best trackers to achieve real-time tracking.

1.1. Challenges in Visual Tracking

1.1.1. The problems in visual tracking

The real context of target tracking system, based on the basement of the three key glitches. **Robustness**: under the frigid conditions, the tracker algorithms should be able to track the target. The

tracking glitches may be cluttered background, partial and full changing illuminations, occlusions origin object motion.

Mutation: The target itself undergoes changes with different environment in each frame. It requires a stable mechanism for tracking system to the actual object appearance.

Implementation: Fast and optimized robust algorithms are required for the frame-rate, which establish smooth video out-put.

1.1.2. Visual tracker

With the specific rigid boundary and transient conditions, the objects a monitor in real time frames. The real time tracker will automatically interpret on the object to monitor and collects the information of the context specified above. The Figure 1 shows the flow diagram of a visual object tracker.

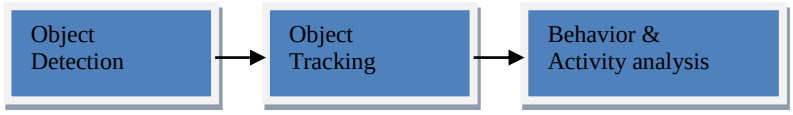

Figure 1. Flow diagram of a visual object tracker

a) Object detection

The object detection can be done in two approaches (1) temporal difference: This method is to subtract the two consecutive frame by frame with a set of the threshold. (2) Background subtraction method: This is to subtract the fore and background or reference model images. The morphologic method is applied to the above approaches to remove the noise in the image.

b) Object tracking

There are two main approaches are used to track the real-time object, one is 2-D model approach another is a 3-D model. The 2-D model track the object by using rectangular model, U-shape model, which consist of an image acquisition module and process the coordinate for single and multiple target trackers. 3-D geometrical model and model-based approach use explicit a priori geometrical knowledge of the object to surveillance for different applications.

Once the model is fixed with varying context such as illumination, occlusions collisions (self). The model-based approaches [4]. Most of the tracking model uses filtering mechanism to detect each movement of recognized object [4-6].

Extended Kalman filters (EKF) or particle filters have been also proposed [5, 7]. HMMs (hidden Markov models) predict and track objects trajectories [8].

c) Behavioral analysis

The final phase of video surveillance system is to monitor the activity and behavior of the target. The time-varying feature data will give the information of the next stage, which it contains pre-compiled measuring sequence library to label the training dataset also called as Deep-leaning model.

2. REVIEW STRUCTURE

The above flow diagram shows, the review structure, and its real-time challenges. All the tracking system will either need two type of input it may be a static image or the dynamic input. The context of the different model show depends on the real-time object appear in the scene.

a) Sec-A. Appearance model

Yang Hua et al. [9] in this paper the appearance model of the ROI object is computed by using HOG feature. In this model, algorithm use bounding box with linear SVM data set for learning and detection of tracking object. The estimating the location of the object with set of positive samples with the bounding box for the first frame and negative bounding box samples automatically. The Figure 3 shows the results of SVM model.

Meijuan Bai1 et al. [10] in this author use, two type of algorithm one is a multi-feature representation (MFR) and classifier-learning model (CLM). Model extract the intensity and pattern feature 71% is the pattern based which are unstable with environment or object's pattern changes. Figure 4 shows the author proposed compressive tracking algorithm. Heng Fan, Jinhai Xiang et al [11], in this paper MJDL (multitask joint dictionary learning) model is used on the target object for extract the

modality feature of corresponding discriminative dictionary. Yong Wang et al. [12] in this paper they proposed a different tracker such as Tracking (IVT), L1 tracking (L1T), L1-APG tracking, multi-task tracking (MTT-L01, MTT-L21), Multiple Instance Learning tracking (MIL), compressive tracking (CT), Wacv12, WMIL, LSST, L2-RLS which analyze the 22 video sequences and compared with the seven state-of-the-art tracking, as shown in Figure 5.

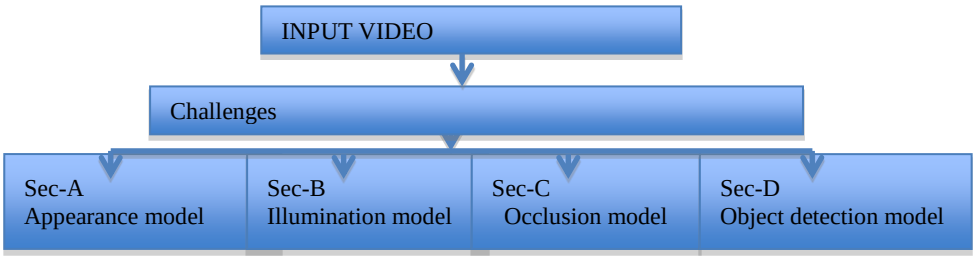

Figure 2. Flow diagram of review structure

Figure 3. Results of SVM TECHNIQUE with bike input image

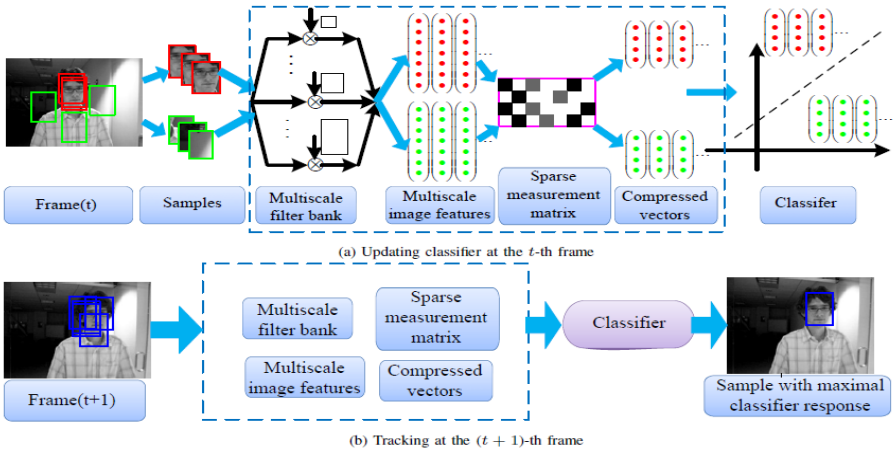

Figure 4. Author Proposed compressive as tracking algorithm

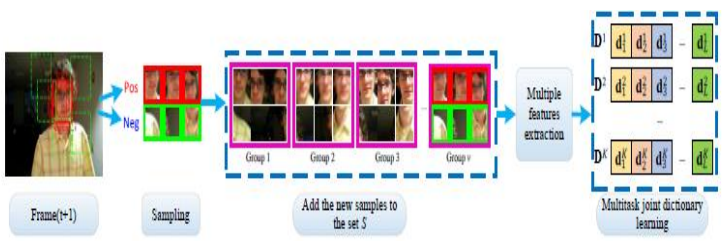

Figure 5. Author Proposed compressive tracking algorithm

Jianghu Lu et al. [13] in this paper the author used the efficient model called CT (compressive Tracking) which track the target and detect. In generative and discriminative model use the compressive domain for the extraction of appearance features. CS sensing reduce adaptive dimension with multi-scale features.

Junseok Kwon et al. [19] in this paper author used different trackers such as VTS, MIL, MIT and ATS for the successful track of target under appearance context. The VTS model is used to track object. ATS model concentrate on degree of varying object. Boris et al. [36] in this paper the author uses the multiple instances learning algorithm MILT, which the set of image patches can be updated with appearance model.

b) Sec-B. Illumination model

ArvindNayak et al. [14] in this paper author uses the auto Correction Scheme that always transforms the image under some unknown illumination to match with the know illumination model. The correction scheme is tested on color and gray level imaging.

SarehShirazi et al. [16] in this paper, the author proposed the Adaptive tracking model which it continuously updates set of affine subspace, and each subspace builds from the object appearance over several consecutive frames. In the new frame, propose a candidate image area for locating object, by including immediate tracking history of other frames. The non-Euclidean geometry of Grassmann manifolds is used between affine subspace from the object model and candidate area to obtain the data.

Junseok Kwon et al. [17] in this paper the author illustrates the tracking of a target with illumination changes using WLMC and OIF model that track abrupt appearance of the object. Figure 6 and 7 shows the results of the proposed tracker.

Figure 6. Author Proposed IVT as tracking algorithm

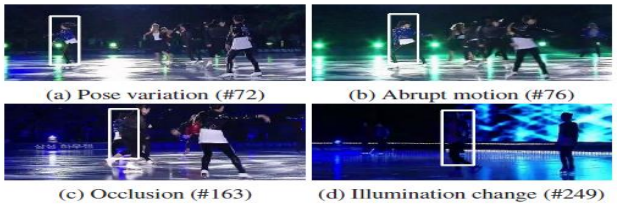

Figure 7. Author Proposed WLMC and OIF model as tracking algorithm

HaoyuRen et al. [18], in this paper author propose model called co-occurrence features based on Haar, LBP, and HOG for the appear detection of the target. It also uses the booster detector which gives high accuracy with computed efficiently. GEB framework is used for discriminative ability, generalization power.

Junseok Kwon et al. [19], in this paper the author novelized the tracking object in each frame with MUG instead of a MAP. The drift problem caused by the noise target can be minimized by conventional MAP-based model. Figure 8 Shows the test results of standard dataset with MUG.

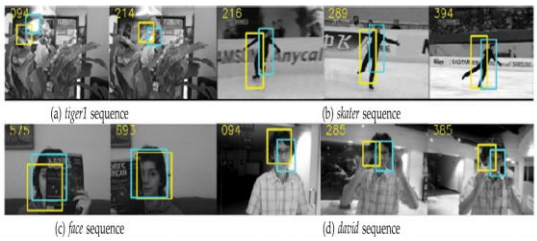

Figure 8. Author Proposed MAP-based as model tracking algorithm

Zhiyong Li, Song Gao and KeNai et al. [20] in this paper the author concentrate on MIL, ODFS, AFS, that tracks the target accurately. The weight of each feature of the target is described adaptively based on ROI object. Table 1 shows the different algorithms.

Xi Chenet al. [21], in this paper the author describes the new visual tracking method based on cognitive and particle filter. In this method, six independent eigenvectors by a model called VOCUS2. This kind of model used on the appearance of moving object with a same background. The average detection rate is 71.8%.

Table 1. Tracking rate different algorithms

TRACKING RATE OF DIFFERENT ALGORITHMS (FPS)

Sequence	CT	MIL	ODFS	AFS	VR-V	Ours
PETS2001	21	3	20	15	17	22
ScaleCar	22	2	20	15	13	17
Intelligent Room	40	4	37	29	26	26
Pedestrian	22	3	17	13	26	18
Car	48	6	42	29	40	28
BlurCar	18	2	15	14	15	16
Average SR	29	3	25	19	23	21

c) Sec-C. Occlusion model

Yichun Shi et al. [22] in this paper author propose tracker based on Ensemble-of-Random Classifiers (TERC) which tracks the object results in state-of-art. The distribution field tracker (DFT), the circulate structure tracker (CSK), the compressive tracker (CT), and the locality-sensitive histogram tracker (LSH) which uses the 10 challenging sequences considering an example on girl, tiger etc. Zhaoyun Chen et al. [23] in this paper the author proposes the extend STC (spatiotemporal context learning) by exploring RGB-D data set. The depth information is introduced with spatial-temporal context model to improve scale estimation, and track occlusion and deformation.

RaedAlmomani et al. [24] in this paper author propose the model called BHAM (Bayesian Hierarchical Appearance Model) which detect the partial and full occlusion. The moving object target is selected and background subtracted with the segment. The KLTfeature connect between blobs in the consecutive frame. Ding Dongsheng et al. [25] this paper proposes a Fusing texture feature model to update the target template with low robust color tacking. This method uses the Particle filter algorithm [28] used for occlusion. Figure 9 show the test results of PFA.

Figure 9. Author Proposed particle filter as model tracking algorithm

ZHU Su et al. [26] in this paper the author proposed the two model novel robust MFT algorithm for saliency mapping. This paper also introduces PF for handing illumination variation, and occlusion. Jin Yuan et al. [27] in this paper author propose novel object tracking algorithm on real-time video. The Fast Fourier Transform [FFT] is used for the extraction of feature template of object. It also used for extraction of current and previous frames. The Figure 10 shows the proposed flow diagram of novel object tracking algorithm on real-time video.

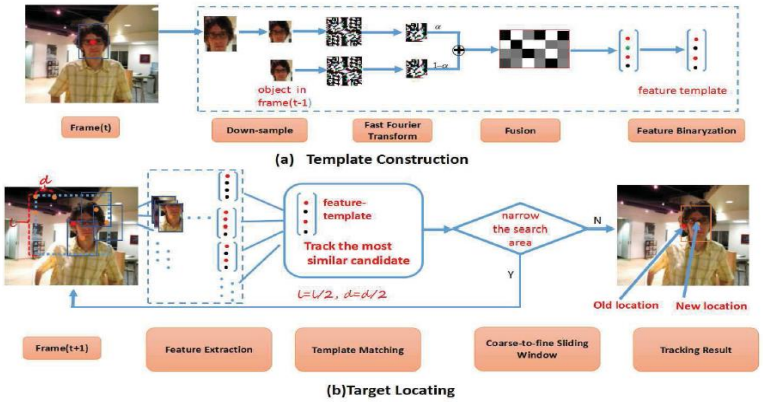

Figure 10. Author Proposed FFT model as tracking algorithm

d) Sec-D.Object detection model

Andreas Ess1 Bastian Leibe et al. [29] in this paper the author proposes the multi-hypotheses approach for the detection of the object. The hypotheses use Kalman filters for analysis of the object. The object with respect to time over complete set of trajectories is estimated with KF model. Figure 11 shows the test results of proposed object tracker of paper.

Figure 11. Author Proposed Kalman Filter model as tracking algorithm

Kalisa Wilson et al. [30] in this paper author proposes the Morphological operation and color segmentation for the detection of moving the object in real time implementation. It also uses thresholding, which used for image processing. Kevin Leahy et al. [31] the paper presented to track an object by using Markov Chain model, that is moving among a finite set of states. At each time instant may search one state for the target. It is known that searching either of the most likely locations for the target is the optimal expectation.

Shengping Zhang et al. [31] this paper proposes The HMAX model uses Gabor filter for detection of the object, where the response of the simple cells was obtained using the second derivative of Gaussian filters. The invariance property of the complex cell is found by max pooling operator. Hiroshi Kera et al. [32] in this proposed paper the author used the HSV color histograms for obtaining the object property. It also uses the RootSIFT Fisher vectors with 64 dimensions for the detection of the object. In video-shot segmentation, the median filter with a kernel size of 15 to a sequence of affinities to cope with outliers.

Yuankai Q et al. [33], in this paper author uses the CNN model for the classification and object recognition task. CNN model like R-CNN, VGG-NET, Alex-NET, and Caffe-NET. Based on the VGG-NET the deeper architecture on data is obtained. Fig.12. shows the author proposed the main steps for handling the object detection using CNN.

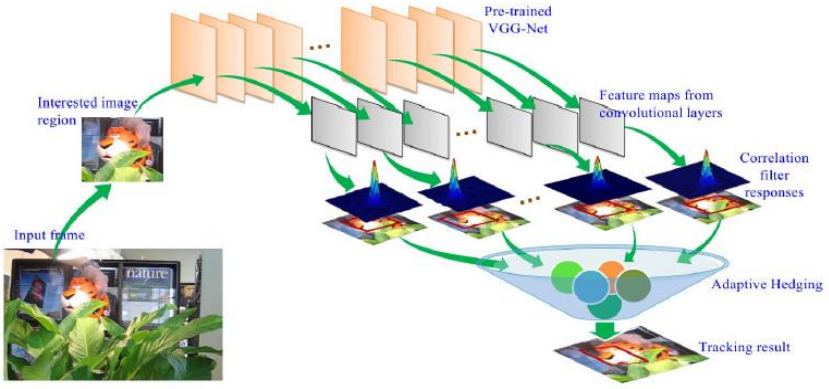

Figure 12. Author Proposed CNN model as tracking algorithm

3. VALIDATION

This paper has presented a comprehensive review of the state-of-the-art on object visual tracking with a various algorithm based on two aspects generative and discriminative. The principle behind this is a number of trackers are proposed over a year in a different application, but which is the suitable tracker, which can be used efficient and accurate, which give high performance to handle the robustness in all conditions. By this review, we came to know the difference between different trackers which is used for different challenges such as abrupt object motion from frame to frame, appearance change, non-rigid object structures, occlusion and illumination with examples.

Table 1. Challenges with different trackers

	CHALLENGES			
	Appearance Model	*Illumination Model*	*Occlusion Model*	*Object detection Model*
Tracker	MILT	CS	TERC, DFT	KF
	HOG	AT	CSK	MORPHOLOGY
	MFR/CL	WLMC, OIF	STC	HMAX MODEL
	MJDL	HAAR, LBP	BHAM	ROOT SIFT
	IVT	MUG	KLT	R-CNN
	MIL	MIL,ODFS	PF	VGG-NET
	CT	AFS	MFTA	
	VTS	VOCUS2	FT	
			CT SW	
			PFF	

Table 2. Represents the tabulation of algorithms; focus area (dataset) used, strength and weakness. The above review and tabulation to a visual tracking algorithm with different context model are hoped to provide beneficial references to researchers and computer vision in a related area

Ref paper num	**Algorithm used**	**Focus Area (Dataset)**	**Strengths**	**Weaknesses**
[4]	Kalman filter	Video surveillance Systems [Human trackers]	Kalman filter increases the time consistency.	Deformations and occlusions occur on the target is the biggest challenge in this algorithm.
[5]	Particle filters	Human trackers Un-manned vehicles, Robot tanning model	Works for any observation model and any motion model Particle filters scale well	Lack of diversity.
[6]	Discrete Kalman Filter	Servo motor	low range view of camera. low FPS (Frame per Second).	Slower settling time.

[7]	Graphical Model for Tracking-by-Detection	Human trackers	Tracking model concentrates on accurate and smooth ego-motion estimate.	Interactions model are used to solve two-stage process.
Ref paper num	**Algorithm used**	**Focus Area (Dataset)**	**Strengths**	**Weaknesses**
[8]	Bayesian Tracking Approach	Human Animals Movie frame	Bayesian analysis can be more robust to outliers, by using more flexible distributions	Complex in implement.
[9]	HOG features	Used on the bike rider Human finger.	By using HOG feature extraction better results can be achieved on edges, cells etc.	It works on single orientation-independent edge presence count.
[10]	Compressive Tracking	Human face	High probability can be achieved on dimensional feature and space using CT	A single feature is used to represent the object. Lack of flexibility, Instability of appearance model.
[11]	Multitask Joint Dictionary Learning	Human face	For sparse re-presentation depth information is provided using MJDL model. It cans handle large data.	Complex in implementation.
[12]	Multi-feature joint sparse Representation	Humans Animals Books in the library.	Captures the frequently emerging outlier tasks in the object.	Complex in implementation.
[14]	SimBIL.	3D model	Refractive index structure constant is modelled by speckle interaction on a rough surface.	SimBIL is a long process and time-consuming.
[15]	Model-based trackers.	Human face [Pedestrians]	The off-line tanning process is used for the tracker.	The limitation of this model in which it can tack set of objects.
[16]	Subspace Based Trackers	Human face On currency note	Multiple objects is represented in a single frame using subspace tracker model.	The larger data set cannot be handled in this model as it has more variation in appearance. Off-line pre-trained data require for tracking the object.
[17]	Markov Chain Monte Carlo	Dancer	High accuracy. Large data can be handling.	Complex to implement. Time-consuming.
[18]	Balanced Co-occurrence Features	Pedestrians	Selection of co-occurrence patterns makes major advantage in RealAda Boost system.	single co-occurrence feature achieve lower accuracy
[19]	Minimum Uncertainty Gap Estimation	Human tracker Sky bird	Highest likelihood score is achieved with best state gap estimation.	Failed to track an object in many test videos.
[20]	Timed Motion History Image [TMHI MODEL] With Multi-feature Adaptive Fusion	Human tracker	For the betterment of target description, HSV color feature and edge orientation feature are used.	Complex in implementation.
[21]	Visual attention system (VOCUS2)	Human Football Face Hand	Better descriptive ability.	Average clearly outperforms
[22]	The ensemble of Random Classifiers (TERC)	Human Bird Tiger	By introducing latent variable, the classifier learns different appearance information, which gives accurate output.	Complex in implementation.
[23]	Spatio-temporal context Learning(STC)	Basketball player	Adopted occlusion detection and region growing method, high Computing efficiency.	Weak in robust object location.
[24]	Bayesian Hierarchical Appearance Model (BHAM)	Human	Can handle full and partial occlusion with superior performance.	Weak in multiple object tracking and deformable objects tracking.
[25]	A particle filter (Particle, PF)	Human	The accurate illumination changes in the tracking of the object are achieved by PF	By using color PF in the tracking of an object, it is more immune to illumination.

[26]	saliency-based target descriptor	Human	This tracker handles illumination, clutter, similar background and occlusion very accurately.	Computation is more.
Ref paper num	**Algorithm used**	**Focus Area (Dataset)**	**Strengths**	**Weaknesses**
[27]	Online learning Algorithm.	CAR David indoor Bolt Coke	For the detection of object, Coarse-to-fine sliding window search algorithm is used.	The only occlusion is detected.
[28]	RGBD Trackers 3D part-based sparse tracker	Human	For the detection of object exploring part-by-part spatial encoder are used.	This tracker is more sensitive to synchronization and registration noise.
[29]	Failure prevention, detection, and recovery mechanisms	Aerial images	It can handle different challenges.	Less speed and performance
[30]	R-CNN features	Dataset of personal interaction with 29-sequences is used.	Pre-training achieved effective tracking of the object.	More data set is required for the improvement of feature description and object-candidate generation.

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